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CONTROL OF THE VETCH BRUCHID IN WESTERN OREGON, WITH SPECIAL REFERENCE TO DDT

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The vetch bruchid (Bruchus brachialis Fahraeus) has greatly reduced the quality and quantity of hairy vetch seed in the area of western Oregon that in recent years has produced more than three-fourths of the American crop of this seed. Production in that area is declining rapidly, and will continue to do so unless methods for the control of the bruchid are found that are economically feasible. This decline has usually been noticeable within 5 years after the insect's first appearance in a seed district. The production of hairy vetch seed has already become unprofitable in about half of the Willamette Valley, and the vetch bruchid is known to occur in all parts of the Valley.

Control of the vetch bruchid in this area is especially difficult because hairy vetch has escaped from cultivation and has become a common weed. Although there is but one generation of the insect a year, the overwintered weevils are long lived and are widely prevalent outside of seed fields. Hence infiltration into fields left for seed occurs over a long period, from the time the first seed pods appear, usually about June 1, until harvest in late July when some pods are still green.

Control experiments conducted from 1940 through 1943 indicated that 90 percent or more of the bruchids actively moving about in a field at the time of treatment could be killed by an application of 25 pounds per acre of a dust containing 0.75 percent of rotenone. A temperature of 67°F. or above is necessary to insure good results. In 1943 a poisoned-bait spray composed of sodium fluosilicate 2.5 percent and sugar 10 percent by weight in water, applied at the rate of 10 gallons per acre, gave similar results under like conditions. However, these treatments reduced the weevil populations in seed fields for only a very brief period, and the results were almost nullified by the infiltration of weevils from outside the treated areas. It became evident that several applications would be necessary to obtain satisfactory control with these materials. Repeated treatments are not economically feasible, since the average crop of clean hairy vetch seed in the Willamette Valley is only about 250 pounds per acre. Furthermore, they would increase the mechanical damage to the crop.

Field experiments in 1944, especially those on the Red Hill Soils Experimental Area at Oregon City, confirmed the conclusions obtained in previous years concerning rotenone dust and bait sprays. These experiments demonstrated that excellent control of the vetch bruchid, even in areas where this insect is extremely abundant, can be obtained with two applications of 3 to 5 percent DDT dusts at 25 or more pounds per acre. They also indicated that one thorough and properly timed treatment of these dusts should give adequate control and a profitable increase in weevil-free seed.

Materials Used

In July 1943 10 pounds of a mixture containing 50 percent of DDT was received from the Division of Insecticide Investigations. This mixture had been prepared by grinding equal weights of DDT and pyrophyllite (Pyrax ABB) in a hammer mill, and contained many small lumps or concretions of DDT. Small amounts of this stock were mixed with Frianite (a volcanic ash) in a mortar to make a series of dusts containing 0.5 to 7.5 percent of DDT, for trial in laboratory experiments during the following winter and early spring. A 5 percent DDT-pyrophyllite dust was also prepared from this stock for use in replicated field-plot experiments at Oregon City during the summer of 1944. A 1 percent rotenone dust and a poisoned-bait spray, prepared by dissolving 4 pounds of sugar in 5 gallons of water and adding 1 pound of calcium arsenate, were also included in the Oregon City experiments.

On June 17, 1944, a supply of factory-mixed 10 percent DDT-pyrophyllite dust was received. A portion of this mixture was diluted with pyrophyllite or Frianite to make a 3 1/3 percent DDT dust,[1]/ and was used on June 20 near Dayton, Oreg.

Laboratory Experiments

Laboratory experiments were carried out at Forest Grove, Oreg., in March, April, and May with vetch bruchids that had emerged in the fall of 1943, and had been kept in cages in an unheated closet over winter. Only weevils that showed normal activity when brought into a warm room were used. In some experiments a straight calcium arsenate dust and dusts containing different percentages of DDT were tested as stomach poisons by applying them at a known rate to paraffin cells (small block of paraffin hollowed out in center) in a dusting chamber. The cells were then filled with dilute honey water and each one was caged with 20 weevils in a clean shell vial. In other experiments DDT and rotenone dusts were tested as contact poisons by applying them at a known rate to small, dry glass dishes and then confining 20 weevils in each dish for 3 days. The poisoned-bait mixtures were either placed in paraffin cells or sprayed onto glass slides, which were placed in large glass cages each containing 100 weevils. Each treatment was replicated at least 5 times. To determine the residual effect, the same paraffin cells or glass dishes used in earlier experiments were again used for fresh lots of bruchids 23 to 24 days after the dust was applied, and after some of it had been removed by weevils killed in prior experiments. Results of these experiments are given in Table 1.

1/ Prepared by the California Spray Chemical Corporation through the courtesy of H. J. Grady.

Table 1.--Mortality of vetch bruchid adults confined in dry glass dishes dusted with DDT or rotenone. Forest Grove, Oreg., 1944

Dust treatment	Dosage per acre	Mortality of adults	
		After exposure for 3 days	Exposed 23 days after treatment
Percent	Pounds	Percent	Percent
Derris			
0.5 Rotenone	30	100 1/	29
0.75 Rotenone	10	100 1/	20
DDT			
0.5	30	95 (5 days)	17
1.0	30	100	37
2.0	30	100	81
3.0	10	100	23
3.0	20	100	83
Check (Frianite)	30	2	5
Differences required for significance			
Odds of 99:1			18
Odds of 19:1			13½

1/ Some alive, but paralyzed, a long time after treatment.

About 30 pounds per acre of a 2 percent DDT dust or about 20 pounds per acre of a 3 percent DDT dust was necessary to obtain a high residual effect against the adult bruchids.

In the experiments in which dusted paraffin cells were filled with honey water, the residue from a 5 percent DDT dust applied at the rate of 30 pounds per acre killed 100 percent of two successive lots of weevils, and 74 percent of a third lot introduced 23 days after the cells were dusted. It was just as effective a stomach poison as the residue from 30 pounds per acre of straight calcium arsenate, which had killed only 73 percent of one previous lot of weevils. The residue from a 3 percent DDT dust originally applied at the rate of 30 pounds per acre killed only 54 percent of the third lot of weevils which was significantly less than that caused by the residue of the 5 percent DDT dust. The residual effect of DDT varied with both the percentage strength and the dosage applied, and for field dusting it was found advisable to use at least 25 pounds per acre of a dust containing not less than 3 percent of DDT. Derris dust containing 0.75 percent of rotenone and applied at 30 pounds per acre killed only 40.6 percent of the second lot of weevils, and its residual effect was therefore much less than that of the 5 percent DDT dust or the calcium arsenate.

In tests with poisoned-bait mixtures the same technique was used as outlined previously. Sodium fluosilicate was found to be less effective than calcium arsenate in a sugar solution, and entirely ineffective after the bait had dried on the slides. As shown in table 2, a bait spray containing as little as 0.5 percent of DDT was as effective as a spray containing 2.5 percent of calcium arsenate, whereas a bait spray containing only 0.05 percent of rotenone was almost as effective as the calcium arsenate spray. Stock molasses from sugarcane used as a sweetening agent appeared to repel the weevils. Solutions of brown sugar and white sugar were equally effective, but residue from the brown sugar solution seemed to have better physical characteristics. There was no difference in attractiveness between 10- and 5-percent sugar solutions. In fact none of the baits could be observed to attract the weevils. Slides sprayed with bait mixtures were caged with weevils both before and after the slides had been air-dried. The mortalities shown in table 2 indicate that, although water in the bait mixtures appeared to be the main attractant, there was considerable feeding on the dried residue.

These experiments indicated that calcium arsenate would be the best poison of those tested and now available for field use in bait sprays, and that a dosage of about 10 gallons per acre would be sufficient. For a single application at this rate the materials should cost not more than half as much as the dusts, and where spraying equipment is available it might be an effective substitute for rotenone dust. For worthwhile control, however, more than one application would probably be needed.

Table 2.—Mortality of vetch bruchid adults caged with sweetened bait sprays containing different poisons. Forest Grove, Oreg., 1944

Poison	Strength	Mortality	
		Liquid bait	Dried bait
	Percent	Percent	Percent
DDT	0.5	99	73
Derris (rotenone)	0.05	85	—
	0.13	—	69
Calcium arsenate	2.5	90	57
Sodium fluosilicate	2.5	86	4
Check (sugar water)	——	16	1

The Red Hill Soils Experimental Area at Oregon City was selected for 1 set of field experiments. This area was divided into 3 courses running north and south, each course containing 23 one-twentieth acre plots. Fifteen of these plots were hairy vetch, interspersed with grain plots or summer fallow. The courses were divided into 3 blocks running east and west. This allowed for 3 replications of each treatment, 1 in each block and 1 in each course. There were also 3 unplotted strips of hairy vetch on the area planted as follows: 1.2 acres east, 0.6 acre west, and 1 acre north of the plots. In order to avoid immediate infiltration of weevils into the test plots after dusting, these strips were also treated. No untreated check plots were left except the hairy vetch that could be found outside the area within a radius of 2 miles. A check was found for a count of eggs on the pods in early July, but by the time of seed harvest all hairy vetch within 3 miles of Oregon City had been harvested for hay. Therefore, volunteer hairy vetch at Forest Grove was used for a check on seed-infestation counts. This vetch had shown almost the same egg count on the pods as the check at Oregon City. The Oregon City neighborhood is known to be one of the sections of western Oregon most heavily infested by vetch bruchids, and 80 percent infestation can be expected in any hairy vetch seed grown in that vicinity.

In these experiments, except as noted below, all dusts were put on at the rate of 22 to 25 pounds per acre, and the bait spray at 10 gallons per acre. About 5 acres were treated with hand equipment at Oregon City, of which 3½ acres were treated twice. It was considerably harder to treat the unplotted strips with hand dusters than it was to treat the small, narrow plots. Consequently they were less thoroughly dusted. The plots in block 1, course 1, dusted twice with 5 percent DDT, received a heavier application on June 8 (35 pounds of the dust mixture per acre) than the plots in the other blocks because they were dusted before the experimental technique was standardized. Five percent DDT dust was applied to the two unplotted strips east and west of the plots on June 7 under cool, cloudy conditions, which conditions we knew from experience were unfavorable for dusting with rotenone or for bait spraying because of weevil inactivity. On June 8 the plots to receive dust were dusted with 5 percent DDT in the morning at a maximum field temperature of about 67° F.; as the sky became overcast and it became too cool for weevil activity, the rotenone dust and bait spray were not applied that day. On June 9, a warm, sunny day with a maximum temperature of 88°, the remaining plots were treated with rotenone dust and bait spray, and the unplotted north strip was treated with the bait spray. All these treatments were put on at about the time the first hairy vetch pods were setting.

Observations made on June 21 showed there had been a large influx of weevils into the plots treated with rotenone dust and bait spray; therefore all the plots were redusted or resprayed on June 23 under very favorable conditions (maximum temperature 83° F.). The unplotted north strip was also resprayed with the bait mixture because of heavy weevil infiltration since the first treatment. The unplotted east and west strips, dusted with 5 percent DDT on June 7, still showed few weevils and were not retreated.

The bruchid populations on all parts of the area were checked by sweeping the hairy vetch at various times before and after dusting. These sweepings gave an indication of weevil movement onto the plots and also the effects of the treatments. However, the activity of the weevils is so dependent on temperature that counts of weevils swept are not dependable enough for statistical analysis. Examination of the ground under the vetch showed that all treatments, especially the DDT, had given good kills. All weevils on the plots treated with dust containing 1 percent of rotenone had been knocked down 3 hours after treatment, but 3 out of 10 weevils found on the ground in these plots 12 days after treatment were alive and able to crawl; however, 2 of these were partly paralyzed. The sweepings, and later the infestation counts, showed that there was a heavy influx of weevils from outside the area, especially from the south and west, between June 10 and 22.

In July counts of eggs on 300 to 400 hairy vetch pods from each treatment, examined in 100-pod lots, were made. The sample pods were collected from plants at intervals of 20 feet on each plot and on a line through the unplotted strips. All the pods were taken from each plant examined. Just before harvest seed samples were collected in the pods, the samples from each plot or unplotted strip consisting of all the pods on plants 10 feet apart. A similar sample was taken from the untreated hairy vetch at Forest Grove, which had shown the same egg count on the pods as the check at Oregon City. Each lot of seed pods was hand-shelled, and the resulting samples of 3 to 8 ounces of clean seed were reduced in a grain sampler to from 0.7 to 1 ounce (800 to 1200 seeds). All the seeds in each of these small samples were examined in 100-seed lots under a binocular microscope for larval entrance holes and the percentages of infestation determined. Seeds containing such holes or bearing suspicious abrasions were counted as infested, even though a considerable number of bruchid larvae die soon after entrance and before the seed is appreciably damaged. The mean coefficient of variation among the 100-seed lots from individual plots was rather high, 20 percent, but when the infestations in 8 to 12 lots of 100 seeds from one treatment were paired with those from another treatment it was possible to show that a difference of at least 10 percent between the mean infestations in the respective treatments was necessary for significance. The results of these counts are given in table 3.

Table 3.--Results of experiments with insecticides for vetch bruchid control, Oregon City, Oreg., 1944

Treatment	Dates of application	Eggs per 100 pods		Infestation of seed		Germination test 3/
		Per plot 1/	Control	Infested seeds per 100 2/	Control	Quick and hard seeds
	June	Number	Percent	Number	Percent	Percent
DDT, 5%						
Plotted:						
Block 1, Course 1	8, 23	36		6.4± .7		93
Block 2, Course 2	8, 23	52		14.2±1.5		81
Block 3, Course 3	8, 23	155		17.7±1.7		82
	Av.	81	92	Av. 12.8	84	Av. 85
Unplotted:						
East strip	7	220		31.1±2.4		66
West strip	7	215		37.0±2.0		59
	Av.	218	79	Av. 34.3	58	Av. 63
Dust, 1% rotenone						
Block 1, Course 3	9, 23	255		33.8±2.3		71
Block 2, Course 1	9, 23	188		28.8±2.0		62
Block 3, Course 2	9, 23	285		35.4±2.8		57
	Av.	243	77	Av. 32.7	60	Av. 63
Calcium arsenate, 2.5%						
Plotted:						
Block 1, Course 2	9, 23	236		32.6±2.7		61
Block 2, Course 3	9, 23	170		33.1±2.3		62
Block 3, Course 1	9, 23	325		46.3±2.3		48
	Av.	244	76	Av. 37.3	55	57
Unplotted,						
north strip	9, 23	216	79	41.4±3.0	50	57
Check (untreated)	July					
2 Mi. S.E.	7	1015	--		--	
Forest Grove	22	1051	--	82.4±2.4		20

1/ Difference between treatment means necessary for significance at odds of 19 to 1 on replicated plots = 67.8.

2/ Difference between means necessary for significance at odds of 19 to 1 on replicated plots = 9.56.

3/ Germination tests by courtesy of Mrs. Louisa A. Kanipe, of Oregon State College. Weevil-damaged seeds not removed. Seeds not fumigated or blown.

The two methods of estimating effectiveness of control gave consistent results, but the percentage of control calculated on the basis of seed infestation was uniformly lower than on the basis of eggs on pods. This was probably due to late oviposition after the egg counts early in July. The counts showed that infiltration of weevils after treatment had been considerable from the south and west, enough in block 3, course 1, treated with the bait spray twice, to cause a highly significantly greater infestation than on the other bait-spray plots. They also showed that the control secured by two treatments with 5 percent DDT had been highly significantly better on block 1, course 1, where the first dust on June 8 was applied at the rate of 35 pounds per acre, than on the other plots where the dust was applied at 22 to 25 pounds per acre. Two applications of 5 percent DDT dust were highly significantly better than 2 applications of 1 percent rotenone dust, or of bait spray containing 2.5 percent of calcium arsenate, 10 percent of sugar, and water, the last two treatments being equally effective. One early application of 5 percent DDT dust on the unplotted east and west strips at the time the pods were beginning to set, even though poorly applied, was equivalent to two applications of rotenone dust or bait spray.

After receipt of the 10 percent dust on June 17, a 10-acre field near Dayton, Oreg., was found available for experimental purposes. The field had been seeded to common vetch but had developed a thick stand of volunteer hairy vetch. On June 20 the 3 1/3 percent DDT-pyrophyllite-Frianite dust was applied to 5.5 acres of this field with a power duster at the rate of 22 to 25 pounds per acre. The maximum temperature was approximately 73°. At least 25 percent of the pods were already formed and many bruchid eggs were present, indicating that the dust was applied too late for best results. June 10 probably would have been the correct date for this application. An untreated check of approximately 4 acres on the north side of this field was delimited by cutting a 16-foot strip of hay. As it was feared that weevils might move into the dusted part from the check, north of the hay strip, a 24-foot buffer strip along the south side of the check was also dusted. Egg counts on the pods were made as at Oregon City. Seed samples were secured at harvest by taking samples from two places in each sack as it was dropped by the combine. The large uncleaned samples, of which about 20 percent was hairy vetch seed, were reduced to workable proportions in a grain sampler, and these small samples were hand-cleaned and examined for bruchid infestation as in the earlier experiments.

Sweeping in all parts of the field after dusting showed that the 3 1/3 percent DDT dust had eliminated practically all of the weevils present in the treated part of the field at the time of dusting, but that some infiltration from the west and south occurred later. The results of the egg- and seed-infestation counts are shown in table 4. The yield of cleaned hairy vetch seed averaged 60 pounds per acre more

on the treated part of the field than on the untreated check. Probably some of the infested seeds were taken out in cleaning, as seeds in which weevils have matured are lighter than uninfested seeds. The control was not so high as it was with one early (June 7) dusting at Oregon City. This is attributed to the fact that about 25 percent of the pods in the Dayton field were well developed and well sprinkled with bruchid eggs at the time of dusting (June 20), whereas only the first pods had recently set at Oregon City on June 7.

Table 4.--Results of late dusting (June 20) with 3 1/3 percent DDT near Dayton, Oreg., 1944

Treatment	Eggs per 100 pods on July 11	Control	Infested seeds per 100	Control	Germination quick and hard seeds 1/	Average yield per acre
	Number	Percent	Number	Percent	Percent	Pounds
DDT dust, 3 1/3%	234	60	32.0	44	81.14	312
Check (untreated)	580	--	57.3	--	75.88	250
Buffer strip	---	--	45.2	21	76.51	295

1/ Seed test made by seed company, after cleaning in mill.

Careful examination of the ground under hairy vetch at Oregon City disclosed that 5 percent DDT had killed insects of several species, including a large phalaenid larva (Caenurgina sp.), three or four species of flies (agromyzids and scatophagids), many beetles (nitidulids, carabids, silphids, elaterids, coccinellids, and Diabrotica 11-punctata Mann.), flea beetles, weevils (Sitona sp. and Brachyrhinus sp.), pea weevils, ants, and spiders. Syrphid and coccinellid larvae, which were abundant, appeared to be unaffected. Pea aphids (Macrosiphum pisi (Kltb.)) were present in large numbers on some of the plots, but only a few appeared to have been killed by DDT. Some of these insects, especially coccinellid beetles, were also found dead on the rotenone dust and bait-spray plots. No dead bees were found and no decrease was noted in the number of honey bees that were swept from hairy vetch dusted with DDT. There were no ill effects on the operators, who found DDT to be much less irritating than the rotenone dusts.

Discussion

Two applications of 3 to 5 percent DDT dust, at the rate of 25 pounds of the mixed dust per acre, gave excellent control of heavy infestations of the vetch bruchid (Bruchus brachialis Fahraeus) on hairy vetch. The results of the experiment near Dayton, Oreg., indicate that one thorough, accurately timed application at the time the first pods set will probably give adequate control in most cases. The residual effect of DDT is especially valuable for bruchid control because of the long period during which the fields are invaded by weevils from outside. Judging from the field trials conducted in 1944, bruchid populations in seed fields probably could

be kept down by repeated and carefully timed treatments with 1 percent rotenone dust, or a bait spray containing 1 pound of calcium arsenate and 4 pounds of sugar in 5 gallons of water. At least two treatments with these materials would be necessary to secure control equal to one application of DDT. Cool, cloudy weather is likely to occur in western Oregon during the very brief period when the first treatment should be put on, and several trials have shown that rotenone dust and poisoned-bait spray are not effective under these conditions. Because of the residual effect of DDT, this material can be applied under such conditions and still be effective.

Several questions still remain to be settled before final recommendations can be made on the use of DDT for the control of the vetch bruchid. Further work is needed to determine the best concentration, inert diluents, dosages per acre, number and timing of applications, effect on other injurious and beneficial insects including bees instrumental in pollination, and the livestock-poisoning hazard of DDT residues remaining on the plants, especially in the event that treated fields are used for hay or pasture instead of for seed harvest.